

**Study
Report
97-06**

The Optimal Job-Person Match Case for Attrition Reduction

Peter M. Greenston, Abraham Nelson, and Darlene Gee
U.S. Army Research Institute

19980311 055

**United States Army Research Institute
for the Behavioral and Social Sciences**



September 1997

100 QUALITY INSPECTED 4

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES

**A Field Operating Agency Under the Jurisdiction
of the Deputy Chief of Staff for Personnel**

EDGAR M. JOHNSON
Director

Technical review by

Mike Fischl
Mark C. Young

NOTICES

DISTRIBUTION: Primary distribution of this report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, ATTN: PERI-STP, 5001 Eisenhower Ave., Alexandria, Virginia 22333-5600.

FINAL DISPOSITION: This report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

REPORT DOCUMENTATION PAGE

1. REPORT DATE 1997, September		2. REPORT TYPE Final		3. DATES COVERED (from... to) January 1996-September 1996	
4. TITLE AND SUBTITLE The Optimal Job-Person Match Case for Attrition Reduction				5a. CONTRACT OR GRANT NUMBER	
				5b. PROGRAM ELEMENT NUMBER 0605803A	
6. AUTHOR(S) Peter M. Greenston, Abraham Nelson, and Darlene Gee				5c. PROJECT NUMBER D730	
				5d. TASK NUMBER 1331	
				5e. WORK UNIT NUMBER H02	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences Selection and Assignment Research Unit 5001 Eisenhower Avenue Alexandria, VA 22333-5600				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Research Institute for the Behavioral and Social Sciences 5001 Eisenhower Avenue Alexandria, VA 22333-5600				10. MONITOR ACRONYM ARI	
				11. MONITOR REPORT NUMBER Study Report 97-06	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT (<i>Maximum 200 words</i>): The purpose of this research is to illuminate an important interaction between personal characteristics and organizational factors as they affect first-term attrition. This study tests the hypothesis that first-term completion is positively related to predicted performance on the job and estimates the attrition reduction that would accompany the utilization of better methods for assigning recruits to jobs so as to improve their predicted performance. The testing is conducted with the 1991 accession cohort using the U.S. Army Research Institute for the Behavioral and Social Sciences' Enlisted Panel Research Data Base (EPRDB). Regression analysis is used to test for a relationship between attrition behavior and predicted performance on the job, holding other factors constant. This relationship is then applied to estimate the attrition reduction that could be brought about by increased soldier performance through improved job-person matching procedures such as the Enlisted Personnel Allocation System (EPAS).					
15. SUBJECT TERMS Job-Person Match Attrition Reduction Proportional Hazards Model First-Term Attrition					
SECURITY CLASSIFICATION OF			19. LIMITATION OF ABSTRACT	20. NUMBER OF PAGES	21. RESPONSIBLE PERSON (Name and Telephone Number)
16. REPORT Unclassified	17. ABSTRACT Unclassified	18. THIS PAGE Unclassified	Unlimited	30	Michael G. Rumsey (703) 617-8275

Study Report 97-06

The Optimal Job-Person Match Case for Attrition Reduction

Peter M. Greenston, Abraham Nelson, and Darlene Gee

U.S. Army Research Institute

**Selection and Assignment Research Unit
Michael G. Rumsey, Chief**

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

September 1997

**Army Project Number
2O465803D730**

**Personnel and Training
Analysis Activities**

Approved for public release; distribution is unlimited.

FOREWORD

The Selection and Assignment Research Unit of the U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) performs research on manpower and personnel issues of particular interest to the U.S. Army. One such issue is attrition reduction. This study report investigates the hypothesis that first-term completion is positively related to predicted performance on the job. The attrition reduction that would accompany the utilization of better methods for assigning recruits to jobs is estimated.

ARI's participation in this effort is part of an ongoing program of research designed to enhance the quality of Army personnel. This work is an essential part of ARI's mission to conduct research to improve the Army's ability to effectively and efficiently manage the force.

ZITA M. SIMUTIS
Technical Director

EDGAR M. JOHNSON
Director

THE OPTIMAL JOB-PERSON MATCH CASE FOR ATTRITION REDUCTION

EXECUTIVE SUMMARY

Research Requirement:

Enlisted first-term attrition rates are in the 30 - 35 percent range, and the Army is intent on better managing and reducing first-term attrition. One way of reducing attrition may be to utilize better methods for assigning recruits to jobs. A major shortcoming of the existing assignment system is its reliance on minimum qualifying scores to determine eligibility for training and job assignment. In consequence, predictable differences among applicants are ignored, and recruits may not be assigned to the jobs for which they are best qualified. This paper examines whether first-term attrition could be reduced by improved job-person match (JPM) through a tool such as the Enlisted Personnel Allocation System (EPAS).

Procedure:

We specify and test a proportional hazards model to examine first-term attrition in the 1991 accession cohort (i.e., excluding DEP attrition) using the U.S. Army Research Institute for the Behavioral and Social Sciences' Enlisted Panel Research Data Base (EPRDB). In so doing we estimate a relationship between attrition behavior and predicted performance. This relationship is then applied to estimate the attrition reduction that could be brought about with increased soldier performance through EPAS. Finally, we estimate the costs versus benefits of utilizing EPAS for attrition reduction.

Findings:

We found general support for the hypothesis that increased predicted performance is associated with reduced attrition rates. The attrition reduction--consequent upon optimized JPM--for the 1991 cohort over the first 36 months is estimated at 368 fewer attritees, with a corresponding recruiting and training cost savings of \$8.5M per year. Due to indivisibilities, this cost savings should be viewed as achievable as part of a larger program of attrition reduction activities. Costs to implement and sustain EPAS, amortized over a 5-year system life, are estimated at \$250K to \$360K per year.

Utilization of Findings:

These findings indicate that improved JPM procedures, even when focused upon optimizing performance, produce indirect attrition reduction effects that are sufficient to justify the implementation of EPAS. Moreover, research to improve the classification and assignment of recruits in a dynamic environment is implementable only if there is an EPAS-like model in place.

THE OPTIMAL JOB-PERSON MATCH CASE FOR ATTRITION REDUCTION

CONTENTS

	Page
INTRODUCTION AND PURPOSE.....	1
METHODOLOGY.....	2
Measures of Attrition.....	2
Proportional Hazards Model.....	4
Analysis Samples and Stratification.....	6
Predicted Performance and Other Covariates.....	7
REGRESSION RESULTS.....	8
ATTRITION REDUCTION EFFECTS OF OPTIMIZED JOB-PERSON MATCH.....	10
Performance Improvement.....	10
Attrition Reduction.....	11
Cost-Savings Due to Reduction.....	12
Net Gain.....	12
REFERENCES.....	15
APPENDIX A. Measuring Attrition.....	A-1
APPENDIX B. CMF Occupational Clusters.....	B-1

LIST OF TABLES

Table 1. Measuring the Attrition Event.....	3
2. Testing the Proportional Hazards Assumption.....	6
3. First-term Attrition Hazard Results.....	9

THE OPTIMAL JOB-PERSON MATCH CASE FOR ATTRITION REDUCTION

Introduction and Purpose

In their recent review of first-term attrition literature, Laurence, Naughton, and Harris (1996) discuss the role of organizational and situational influences in addition to that of personal characteristics. They mention several examples: individuals, with higher education levels and AFQT scores, who are college bound tend to complete a term, most likely to capitalize on education benefits; youths who enlist through the buddy plan are more likely to complete the term, as are women in occupations with a higher and more supportive female mix; and high school graduates may be better matched to their jobs than non-graduates. Of particular relevance is this point: "the finding that job satisfaction is related (to later attrition), as well as the findings that individual variables interact with situational variables, suggest that better matches between individuals and organization and job characteristics are worthwhile attrition interventions" (p. 11). This serves as our starting point.

The purpose of this research is to illuminate what we believe is an important interaction between personal characteristics and organizational factors as they affect first-term attrition. The notion is that the assignment of individuals to jobs for which they have relatively high aptitude (versus assignments based on meeting minimum aptitude requirements) should result in more productive and satisfied recruits, more likely to complete their first term. In this study we test the hypothesis that first-term completion is positively related to predicted performance on the job, and we estimate the attrition reduction that would accompany the utilization of better methods for assigning recruits to jobs (so as to improve their predicted performance).¹

The relationship between job performance and turnover has recently been reviewed in a meta-analysis by Williams and Livingstone (1994). Their results suggest that the relationship between individual performance and voluntary turnover is complex. They conclude that the negative linear relationship between performance and voluntary turnover is robust, although a positive

¹ An analogous approach on the non-cognitive side is suggested by Laurence et al. in their review. They point out that while biodata and temperament inventories have not been implemented as a selection screen owing to potential stability and compromise problems, such problems may not arise if these instruments are used for classification. They could make an important contribution to attrition if used to secure better matches between individuals and jobs, or at least to steer recruits away from poor job choices (p. 16).

relationship between performance and voluntary turnover cannot be ruled out under certain conditions. In other words, in most companies, poorer performers will be more likely to voluntarily quit their jobs than better performers. The effects of moderators (i.e., covariates) were also examined. Reward contingency was the strongest moderator found. When rewards were contingent on performance the negative relationship between performance and voluntary turnover was accentuated. They also found that unemployment rates had little effect on the magnitude of the negative relationship -- a finding at odds with other studies -- and suggest that the specific influence of alternative job opportunities requires continued examination.

The plan of the paper is as follows. In the second section we describe the methodology -- the measurement of attrition, the attrition model, the analysis samples, and the explanatory variables. In the third section the regression results are summarized. In the fourth section we apply the model to estimate the attrition reduction effects of optimized job-person match procedures.

Methodology

Measures of Attrition

This study is concerned with first-term enlisted attrition in the Army -- both the "if" and "when" of attrition. Attrition connotes premature separation, i.e. those soldiers who leave prior to completion of their initial obligation; this obligation ranges between 24 and 72 months.² Table 1 describes how attrition is measured in this study. Refer to Appendix A for more detailed information on measuring attrition with Interservice Separation Codes (ISC).

The analysis data set consists of information on the FY 1991 soldier cohort, observed for the occurrence of attrition over the first 36 months of the enlistment term -- that is, we utilize a 36 month observation period. Figure 1 depicts the four observable cases of soldier behavior. The solid line represents staying behavior that is observed and utilized in the model estimation; the dotted line represents either staying or leaving behavior that is censored or not utilized in the estimation; and the "x" represents the attrition event. Soldier A completes a first term during the observation period -- for example, this can occur when the initial obligation is 24 months, and subsequent staying/leaving behavior is censored. Soldier B remains in the Army serving his/her first term during the entire observation

² Those soldiers who obtain an early release are treated as if they had completed the initial term of obligation. Immediate reenlistment before ETS accounts for the vast majority of early release cases.

Table 1: Measuring the Attrition Event

Completed first-term

- If the person stayed in 36 or more months and if DUTYDATE is not missing.

As if completed

- Immediate reenlistment
- Release from active service
- Unknown or invalid ISC codes

Did not complete

- If the person stayed in the service (SEPDATE - DUTYDATE) less than 36 months.

Attrition (non-pejorative)

- Medical disqualifications (disability)
- Death
- Entry into officer programs
- Retirement (other than medical)
- Other separations or discharges
- Transactions (MIA/POW, record correction)

Attrition (pejorative)

- Medical disqualifications
 - Dependency or hardship
 - Failure to meet minimum behavioral or performance criteria
 - Other separations or discharges
 - Transactions (desertion, imprisonment, etc.)
-

period, and subsequent staying/leaving behavior is censored. Soldiers C and D are cases of pejorative and non-pejorative attrition, respectively. When attrition occurs under non-pejorative circumstances (see Table 1), the observations are censored at the point of separation. These are circumstances where the soldier is deemed not to be at fault. We do not want to treat non-pejorative separation as an attrition event, and we do not want to exclude these cases and lose the information (prior to separation).

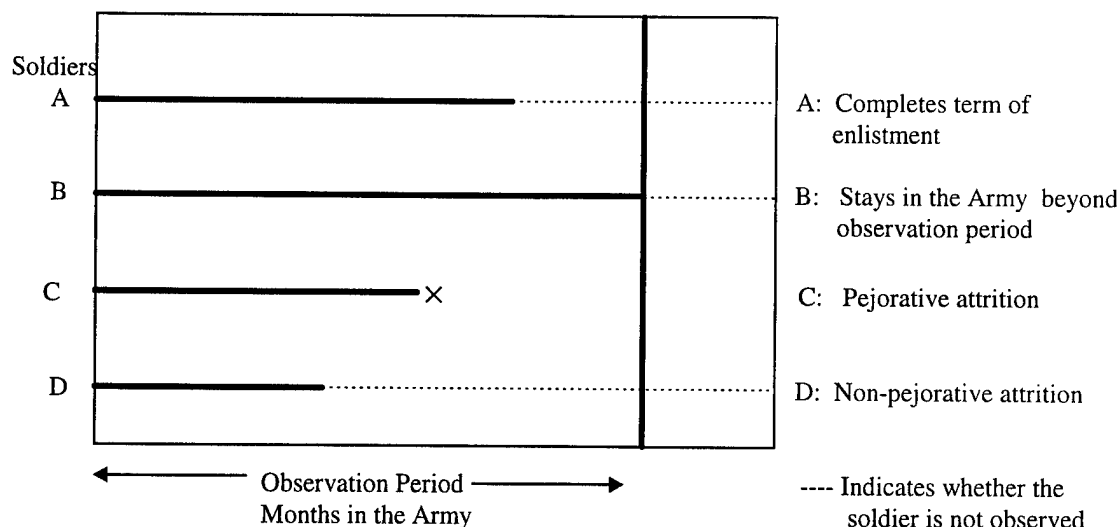


Figure 1: Examples of observed behavior of first term enlisted soldiers

The two most viable approaches for examining the timing of attrition are logistic regression and event history analysis. There are, however, two features of logistic regression models that make them less useful. Logistic regression models do not accommodate time varying covariates or censored observations. In this study there are no time-varying covariates, but there are censored observations. Using logistic regression models would necessitate excluding the Soldier D cases. Furthermore, to estimate the timing of attrition using logistic models would require different models for each time unit of interest. For example, one might estimate a 6-month model, a 12-month model, and a 36-month model. Because of these shortcomings logistic regression is not used here.

Proportional Hazards Model

Event history analysis is a method for studying the timing of the occurrence of events such as attrition. It accommodates time-varying covariates and censored observations. It is a statistical technique well-suited to studying the attrition behavior of soldiers in which (a) a qualitative change in the event of interest can be localized in time and (b) longitudinal records of when the event occurs exist for individuals.

Event history models involve two basic functions of time -- hazard and survival functions. Let length of service be represented by the random variable T . Suppose that T has a continuous probability distribution, $f(t)$, where t is a realization of T . The cumulative probability is $F(t)$ and represents the $\text{Prob}(T \leq t)$. The probability that the length of

service is of length at least t is given by the survival function $S(t) = 1 - F(t)$. For time measured continuously³, the hazard rate, $h(t)$, is given by

$$h(t) = f(t) / S(t).$$

The hazard rate indicates the rate at which length of service is completed (i.e., the rate at which attrition occurs), given that it lasts at least until t .

We utilize Cox's (1972) proportional hazard specification which allows the hazard rate to vary with observable and unobservable characteristics of the soldier:

$$h(t) = h_0(t)e^{-\beta X}\epsilon,$$

where X is a vector of explanatory variables, β is a vector of coefficients to be estimated, ϵ reflects unobservable characteristics that do not change during the period, and the $h_0(t)$ term -- called the baseline hazard rate -- represents effects of length of service thus far.⁴

The Cox proportional hazards model is more flexible than other event history analysis models, and is called semi-parametric because the baseline hazard function does not have to be specified. The model derives its name from the fact that for any two individuals at any point in time, the ratio of their hazards is assumed constant. Allison (1984) argues that this is not a crucial feature because the hazards cease to be proportional once time-varying explanatory variables are introduced, i.e., when $x = x(t)$. When the proportional hazards assumption is not met, the sample can be divided into strata according to the variable that varies over time. A separate model is then postulated for each stratum: the models share the same regression coefficients but each has a different baseline hazard.

³ If time is measured discretely then the hazard function describes the conditional probability that the event occurs for an individual (or group) in a given time interval, given that the individual is at risk (i.e., the event has not already occurred).

⁴ Underlying this statistical model is a net utility framework; refer to Warner and Solon (1991). The new soldier is assumed to remain in the Army as long as his/her net utility is positive. Net utility is the sum of pecuniary and non-pecuniary gains from staying in the Army. Both gains are expressed as linear functions of observable and non-observable characteristics, which collapse into the βX 's and ϵ . Any particular characteristic may influence attrition through its relationship to pecuniary and/or non-pecuniary gains. Accordingly, we observe the net effect of several underlying effects that may operate in different directions.

The regression coefficients are estimated using a partial likelihood method devised by Cox that does not require estimation of $h_0(t)$. The baseline hazard is treated as an individual (or group) specific constant.

Analysis Samples and Stratification

We examine the FY 1991 Regular Army NPS (non-prior service) accession cohort (i.e., excluding DEP attrition) using the Army Research Institute's (ARI) Enlisted Panel Research Data Base (EPRDB). This is a longitudinal file which has been updated through September 1994.

Results of the proportional hazards assumption testing are shown in Table 2. The testing consists of regressing attrition against time interacted with each variable of interest. It indicates that we should stratify by gender and high school graduate status (as well as by certain occupation groups), allowing for different baseline rates, or estimate separate equations for male/female and graduate/non-graduate groups. We actually estimated separate equations for all females, male graduates and male non-graduates.⁵

Table 2: Testing the Proportional Hazards Assumption

<u>Time interacted with:</u>	<u>Probability of Chi-square</u>
SEX	.0001
HSGRAD	.0001
Administration	.1766
Aviation	.0208
General Engineering	.1299
General Science	.0005
Health	.0005
Mechanical Maintenance	.1905
Military Intelligence	.2491
Military Police	.0001
Military Science	.0001
Signal	.0001
Supply	.0617
Transportation	.0203

The male graduate set was subdivided by career management field (CMF) occupational clusters: military science, mechanical maintenance, health, signal, supply, administration, military intelligence, military police, general science, transportation,

⁵ High school graduates refer to diploma holders -- we exclude G.E.D. and alternate credential holders, as well as those who did not receive diplomas but did complete one year of college.

general engineering, and aviation.⁶ The testing indicated this to be appropriate for at least six of the clusters. Separate proportional hazard (PH) models were estimated for each cluster using military occupational specialty (MOS) indicator variables so as not to confound the analysis with attrition differences across occupations. This is equivalent to stratifying each CMF cluster on MOS.⁷

Predicted Performance and Other Covariates

The major variable of interest is predicted performance on the assigned job (PPACT). Indeed, the other variables are utilized primarily to ensure defensible testing for the effects of PPACT. This variable is a weighted sum of standard scores on the Armed Services Vocational Aptitude Battery (ASVAB) subtests and is based on recent classification research conducted by Zeidner, Johnson, and Vladimirovsky (1995, pp. 29-30). In this work the authors first identify 66 job clusters⁸ which span the existing MOS and are relatively homogenous, and then for each cluster estimate least-squares coefficients which best relate ASVAB subtests to skill qualification test (SQT) scores (the measure of performance) using soldier test data collected during the 1986-87 period. We use these estimated coefficients to create a PPACT score for each observation in the analysis sample. Accordingly, the higher a soldier's overall aptitude and the higher the soldier's particular aptitudes for the job to which he or she has been assigned the higher will be the PPACT score.

A rather weak correlation with the Armed Forces Qualification Test (AFQT) score has been reported in the attrition literature (Laurence et al., p.5). Nevertheless, we wish to hold constant overall aptitude when estimating performance effects. Following McCloy et al. (p. 26) we have created separate measures of quantitative (QUANT) and verbal (VERBAL) aptitudes. QUANT is the sum of arithmetic reasoning (AR) and mathematics knowledge (MK) subtests; VERBAL is the sum of word knowledge (WK), paragraph comprehension (PC), and general science (GS) subtests.

We used several variables to hold constant the effects of enlistment conditions: entry with a waiver (WAIVER); selection of only the guaranteed training option (T-ENL); membership in junior

⁶ The clusters are defined in Military Occupational Classification and Structure, Update 12-6, AR 611-201, June 1995, p. 7. The clusters and their associated CMFs are shown in Appendix B. Regression results are reported for 12 of the 17 clusters. The excluded ones are low-density MOS.

⁷ McCloy, DiFazio, and Carter (1993) divide their sample by combat versus non-combat MOS and 3 versus 4 year enlistment term, and test the proportionality assumption for individual MOS within each subsample.

⁸ The Zeidner clusters are collections of MOS that fit within (i.e., do not cross) the CMF clusters described.

ROTC program (YOUTH); and number of months in the delayed entry program (MONSDEP). Demographic effects were held constant with: age (AGEENTRY) and age squared; a variable indicating single marital status (SINGLE); and variables for race-ethnicity (BLACK, HISP).

Regression Results

We summarize the regression results in Table 3 by showing the percentage change in the hazard rate in response to a one unit change in the independent variables. These are derived from the estimated coefficients as $100 * (e^{\beta} - 1)$. Note that only the statistically significant effects are shown, except for the PPACT variable for which all the transformed coefficients are shown. For example, an increase of 1 point in QUANT for HS grad recruits in military science occupations decreases the hazard of first-term attrition by 1.8% of its current value, and the impact of a 1 point increase in PPACT is a decrease in the first-term hazard by 21.3% of its current value. Note that PPACT is the only variable measured in standard deviation units, and a one point change is a dramatic one. A 0.3 SD unit change would decrease the hazard by 6.9% ($100 * (.787^{0.3} - 1)$) of its current value.

We found general support for the hypothesis that improvements in performance tend to lower the hazard rate: PPACT risk ratios (not shown) are less than one in all equations, and statistically significant for 5 of the 12 CMF clusters of male HS graduates and for females (all graduates) as well.⁹ These "significant" clusters account for approximately 75 percent of the entire cohort. We found significant effects of QUANT in most of the equations, with higher values tending to lower the hazard rate; VERBAL was significant in only three equations, and had the opposite effect. This corroborates the findings of McCloy et al. (p. 26), and suggests, other things equal, that a narrower construct of aptitude is related to completion. Single marital status and black or Hispanic race-ethnicity played significant roles in most of the equations, working to lower the hazard rate

⁹ Performance may also play a role in the reenlistment decision. Brown (1991) examines how various features of the Army's personnel system affect the quality of those who reenlist. His study focuses on 1985-87 decisions made by soldiers in infantry, mechanical maintenance, and administration occupations. He reports that soldiers with higher SQT scores are generally more likely to reenlist, whereas those with high AFQT scores are decidedly less likely to reenlist. High school graduates in infantry and administration also appeared less likely to reenlist.

Table 3:

First-term Attrition Hazard Results (percentage change for a 1 unit change in the independent variable)

	Male High School Grads	Quant	Verbal	PPACT	Monsdep	Age	Single	Waiver	T-Enl	Black	Hispanic
Military Science	-1.8 ***	-21.3 ***					-25.0 ***	14.5 ***		-14.6 ***	-35.6 ***
Mechanical Maintenance	-2.0 ***	-9.9 *			19.73 **		-19.0 ***	15.0 **	12.5 *	-21.9 ***	-34.3 ***
Health	-1.4 ***	-19.2						18.3 **	21.0 ***	-30.0 ***	-27.5 ***
Signal Corps	-1.3 **	1.2 **			1.8 **	41.13 ***	-19.2 **			-37.4 ***	-51.7 ***
Supply	-1.5 ***	-18.8						25.1 **		-36.6 ***	-42.1 ***
Administration		-18.6								-28.2 ***	-39.4 ***
Military Intelligence	-2.6 **	2.2 *				-24.7 *					
Military Police		-39.3 **						44.8 **			-50.6 **
General Science	-1.9 *	-17.4					-30.5 *			-42.3 ***	
Transportation	-2.2 ***	-18.2		3.9 ***					28.7 **	-44.6 ***	
General Engineering		-28.3 *									-47.4 **
Aviation		-26.6					-27.2 **				
<u>Male Non HS Grads</u>	-1.2 **	-13.4		1.6 *						-21.8 **	-34.9 ***
<u>Females</u>	-1.4 ***	1.4 ***		-15.6 **			-27.4 ***	13.0 *	14.0 ***	-46.0 ***	-43.0 ***

PPACT measured in standard deviation units.

* indicates statistical significance at 0.10 level

** indicates statistical significance at 0.05 level

*** indicates statistical significance at 0.01 level

(e.g., in health occupations, the hazard rate for blacks is 70% that of non-blacks). Entrance with a waiver played a significant role in many of the equations, tending to increase the hazard rate. The remaining variables entered significantly in only a few equations.

Attrition Reduction Effects of Optimized Job-Person Match

In the early 1980's a Congressional mandate to examine the effectiveness of the current selection system led to a DoD directive to link enlistment standards to job performance (Green, Wing, and Wigdor, 1988, pp. 1 - 11). In response the Army launched a multi-faceted research program with the goal of maximizing total Army effectiveness through efficient use of available personnel resources. The first component of the Army's program, known as Project A, was designed to validate the existing selection and classification battery (ASVAB), and to develop and validate measures of job relevant attributes outside ASVAB's realm, such as spatial and psychomotor ("can do") tests as well as motivation and socialization ("will do") tests (Campbell and Zook, 1991). At the same time, effective selection and classification measures by themselves were recognized as insufficient for bringing about improved personnel utilization. The next essential step was to build a system which used these measures to make the best possible personnel assignments. To bring this about, a research effort known as the Enlisted Personnel Allocation System (EPAS) was launched in parallel with Project A in 1982 and completed in 1990. The effort was revived several years later, resulting in the present prototype PC-EPAS model (see Rudnik and Greenston, 1995).

Performance Improvement

A major shortcoming of the existing assignment system, then and now, is its reliance on minimum qualifying scores to determine eligibility for training and job assignment (i.e., suboptimal use of the ASVAB test battery). In consequence, predictable differences among applicants are ignored, and recruits may not be assigned to the jobs for which they are best qualified.

EPAS is a linear programming (LP) model designed to introduce optimization into the job-person-match (JPM) process. The objective of the LP is to maximize soldier performance.¹⁰

In the current version of the prototype, performance is approximated by a soldier's aptitude area (AA) composite score in

¹⁰ In its operational mode EPAS is a part of the REQUEST Hierarchy system. It should be viewed as an enhancer of that system. It works to nudge REQUEST toward optimal JPM. Its use is totally transparent to the guidance counselor and the recruit.

the job to which he or she has been assigned. The performance gains demonstrated by PC-EPAS amount to an increase of 3.17 points in the overall average AA scores of the assigned soldiers. These results derive from optimization and simulation using actual enlistment contracts data (the FY 1991 accession cohort matched into jobs available during FY 1991 and 1992). Comparison is with the cohort average resulting from the actual assignments made by the existing system.

The 3.17 point AA increase translates into an increase of 0.092 SD units, using the mean predicted performance (MPP) metric. This gain is the tip of the classification research iceberg -- so to speak. Current and previous research strongly suggest additional gains from better measures of performance. Replacing the unit weighted AA composites with full least squares weights (developed from regressing ASVAB subtests against SQT performance) produces gains in the neighborhood of .080 SD (for examples: Johnson, Zeidner, Vladimirovsky, 1996, p. 20; Nord and Schmitz, 1989, p. 3-34). Additional gain of .062 SD is suggested by the use of a larger set of job families in the classification procedure (Johnson, Zeidner, Vladimirovsky, 1996, p. 23). These potential gains sum to 0.234 SD units.¹¹

The productivity gain demonstrated by PC-EPAS could be realized in today's operating environment. It is not predicated on any change in current personnel policies, quality targets, etc. The prototype model includes essentially all the real-world operating constraints. PC-EPAS does require a monthly recruit supply forecasting capability, but this not a new capability and would not be difficult to develop and maintain. In the meantime U.S.Army Recruiting Command (USAREC) mission boxes can be used as forecasts.

Attrition Reduction

This analysis focuses on the attrition reduction that would be obtained via EPAS from optimized job-person-match (JPM) and the consequent improvement in soldier performance. As described above, the approach is to estimate attrition regression equations using Enlisted Master File (EMF) explanatory variables, and a measure of soldier performance in the job to which the soldier has been assigned. Performance scores vary with the individual's overall aptitude and the congruence between the assigned job and those aptitudes. We tested and confirmed the hypothesis that the attrition hazard rate varies inversely with performance, holding other factors constant. With this finding, plus the PC-EPAS demonstration results as well as previous and current classification research, we can infer the likely impact of

¹¹ The current prototype has successfully been extended to utilize predicted performance (PP) scores rather than AA scores with a preliminary set of 66 new job families and full least squares composites developed by Johnson, Zeidner, and Vladimirovsky. This model produces gains in MPP of 0.21 SD, very similar to what is expected based on prior research.

optimized JPM upon attrition reduction, and calculate the cost-savings associated with EPAS.¹²

As previously discussed, a reasonable estimate in the amount of improvement in soldier performance that can be anticipated with optimized JPM is 0.234 SD. The mean effect upon attrition of this performance improvement can be calculated by applying the estimated coefficients to the change of 0.234 SD in PPACT and the mean values of the other variables. The estimated average impact for the FY 1991 cohort over the first 36 months is 368 fewer attritees (the 90 percent confidence range is 81 to 657).

Cost-Savings Due to Reduction

To estimate the cost-savings we utilize 1995 Military Personnel Account (MPA) cost factors found in the Army Manpower Cost System (AMCOS) maintained by the Cost & Economic Analysis Center (USACEAC). Average recruiting and initial-entry training costs are \$9,559 and \$13,415, respectively. Thus, the mean recruiting and training cost-savings due to 368 fewer attritees comes to \$8.5M per year. Due to indivisibilities, especially in training, this cost-savings should be viewed as achievable as part of a larger program of attrition reduction activities.¹³

Net Gain

We have taken a conservative approach to the estimation of the costs to implement, deploy, and sustain the EPAS system. Implementation (\$525-850K), deployment (\$100K), and sustainment (\$100-150K/year) costs have been added together and amortized over an assumed five year system life to produce an annual average cost of \$250-365K.¹⁴

The dollar benefits from EPAS have been described. At a minimum, we can point to only the cost-savings due to attrition reduction, and within that to only the recruiting and training cost savings. This comes to \$8.5M per year. Thus, at a minimum,

¹² The attrition reduction described in this paper can be referred to as indirect, in the sense that it is a by-product of the increase in soldier performance. Direct attrition reduction would result from an EPAS optimization in which the objective function is to minimize predicted attrition. Additional research is underway to specify the attrition equation(s) for insertion into the objective function.

¹³ If we include all costs associated with first-term soldiers, the mean cost-savings is \$12.3M, using average total MPA costs of \$30,883 for E1-E3 and \$38,931 for E-4. This all costs estimate, however, is something of an overestimate because it ignores the value of post-training output produced by the attriting soldiers.

¹⁴ A small remainder of R&D costs (\$120K) are also included. Sustainment costs exclude in-house staff costs associated with maintaining the recruit supply forecasting capability.

benefits exceed implementation and sustainment costs by a margin of more than \$8M per year. In addition, if one allows productivity improvements to enter the calculation, the margin grows to approximately \$40M per year.¹⁵

Finally, it should be emphasized that research to improve the classification and assignment of recruits in a dynamic environment will be implementable only if there is an EPAS-like system in place. The present system of static cut-scores cannot be expanded or made smart enough to meet the requirement. The enhancement of REQUEST with EPAS will also necessitate (and in so doing present an opportunity for) greater coordination among the parties concerned with recruiting management.

¹⁵ One way to evaluate the improved performance made possible by EPAS is to ask what it would cost to achieve the increased performance using existing assignment procedures -- i.e., what is the cost of replacing enough CAT IIIBs with I-IIIBs to bring about the equivalent improvement? Consider the immediate gain of 0.092 SD achieved with PC-EPAS. A gain of the same magnitude is reported by Nord & Schmitz in an earlier simulation carried out using the 1984 cohort. Their opportunity cost estimate is \$81M (N&S, 1989, p. 3-52), and includes savings from reduced attrition. If we reduce their estimate by 50 percent to account for the difference in cohort sizes between 1984 and now, our estimate is still \$40M per year (1984 dollars). Moreover, if we take into account better performance metrics, the estimate is dramatically larger.

REFERENCES

- Allison, P. D. (1984). Event history analysis: Regression for longitudinal event data (Sage University Paper 07-046). Beverly Hills, CA: Sage Publications.
- Brown, C. (1991). The quality dimension in Army retention. In C. Gilroy, D. Horne, and D. Smith (Eds.), Military compensation and personnel retention: Models and evidence. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Campbell, J. P., and Zook, L. M. (Eds.). (1991). Improving the selection, classification, and utilization of Army enlisted personnel: Final report on Project A (ARI Research Report 1597). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA 242 921)
- Cox, D. R. (1972). Regression models and life tables. Journal of the Royal Statistical Society, Series B34, 187-202.
- Green, B. F., Jr., Wing, H., & Wigdor, A. K. (Eds.). (1988). Linking military enlistment standards to job performance. Washington, DC: National Academy Press.
- Johnson, C., Zeidner, J., & Vladimirovsky, Y. (1996). Developing classification-efficient job families using differential assignment theory techniques (ARI Study Report). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Laurence, J. H., Naughton, J. A., & Harris, D. A. (1996). Attrition revisited: Identifying the problem and its solutions (ARI Research Note 96-20). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA 309 172)
- Manganaris, A. G., & Schmitz, E. J. (1984). Projecting attrition by military occupational specialty (ARI Technical Report 637). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA 168 183)
- McCloy, R. A., DiFazio, A. S., & Carter, G. W. (1993). Prediction of first-term military attrition using pre-enlistment predictors. Paper presented at the meeting of the American Psychological Association, Toronto.

- Nord, R. D., & Schmitz, E. J. (1989). Estimating performance and utility effects of alternative selection and classification policies. In J. Zeidner and C. D. Johnson, (Eds.), The economic benefits of predicting job performance. Alexandria, VA: Institute for Defense Analyses.
- Rudnik, R. A., & Greenston, P. M. (1995). Development of an Army prototype PC-based enlisted personnel allocation system (ARI Study Report 96-03). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences. (ADA 304 913)
- Warner, J. T., & Solon, G. (1991). First-term attrition and reenlistment in the U.S. Army. In C. Gilroy, D. Horne, and D. Smith (Eds.), Military compensation and personnel retention: Models and evidence. Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences.
- Williams, C. R., & Livingstone, L. P. (1994). Another look at the relationship between performance and voluntary turnover. Academy of Management Journal, 37(2), 269-298.
- Zeidner, J., Johnson, C., & Vladimirovsky, Y. (1995). Improving the classification efficiency of the ASVAB: Review of findings and recommendations for the Army Research Institute. Washington, DC: George Washington University.

Appendix A

Measuring Attrition

I. COMPLETION CODES

If a soldier completed the first term of enlistment, then we assigned him or her a completion code equal to "1". (Comp(x) = 1)

X represents the variable for length of time in months.

If a soldier did not complete the first term of enlistment (and left for pejorative reasons), then we assigned him or her a completion code equal to "0". (Comp(x) = 0)

If a soldier did not complete the first term of enlistment, but left the Army for non-pejorative reasons, then we assigned him or her a completion code equal to "9". (Comp(x) = 9)

II. SUMMARY OF DETAILED INFORMATION FOR EACH COMPLETION CODE

Completed the First Term (Comp(x) = 1).

If the person stayed in $\geq x$ months and if DUTYDATE is not missing.

As if Completed the First Term (Comp(x) = 1).

Immediate reenlistment

Unknown or invalid ISC code

Release from active service (ETS or early release for various reasons)

Pejorative Attrition (Comp(x) = 0).

If the person stayed in the service (SEPDATE - DUTYDATE) less than x months.

Other reasons:

Medical disqualifications

Dependency or hardship

Failure to meet minimum behavioral or performance criteria

Other separations or discharges (marriage, minority, conscientious objector, parenthood)

Transactions (dropped from strength for desertion, for imprisonment, for other)

Non-Pejorative Attrition (Comp(x) = 9)

Medical disqualifications (disability)

Death

Entry into officer programs

Retirement

Other separations or discharges (sole survivor, pregnancy, erroneous enlistment, etc.)

Transactions (record correction, MIA or POW)

III. DETAILED INFORMATION FOR EACH COMPLETION CODE

Completed the First Term (Comp(x) = 1).

If the person stayed in $\geq x$ months and if DUTYDATE is not missing.

As if Completed the First Term (Comp(x) = 1).

If $\text{Comp}(x) = 0$ and if $(0 \leq \text{ISC} \leq 8 \text{ or } \text{ISC} = 100)$, then the person completed the first term.

ISC codes:

0 - Unknown or invalid

Release from active service:

1 - expiration of term of service

2 - early release - insufficient retainability

3 - " - to attend school

4 - " - police duty

5 - " - in the national interest

6 - " - seasonal employment

7 - " - to teach

8 - " - other (including RIF)

Transactions:

100 - immediate reenlistment

Pejorative Attrition (Comp(x) = 0).

If $\text{Comp}(x) = 0$ and if $(\text{ISC} = 10, 16, 17, 22, 93, 95, 96, 97, 101, 102, 105 \text{ or } 60 \leq \text{ISC} \leq 87)$, then the person attrited for pejorative reasons.

ISC codes:

Medical disqualifications:

10 - conditions existing prior to service

16 - unqualified for active duty - other (after 10/85)

17 - failure to meet weight/body fat standards (included in code 16 prior to FY85)

Dependency or hardship:

22 - dependency or hardship

Failure to meet minimum behavioral or performance criteria

60 -- 87

Other separations or discharges:

93 - marriage

95 - minority

96 - conscientious objector

97 - parenthood

Transactions:

101 - dropped from strength for desertion

102 - dropped from strength for imprisonment

105 - other dropped from strength/ the rolls

DETAILED INFORMATION FOR EACH COMPLETION CODE (cont.)

Non-Pejorative Attrition (Comp(x) = 9)

If Comp(x) = 0 and if (11<= ISC <= 15 or 30 <= ISC <= 33 or 40 <= ISC <= 42 or 50 <= ISC <= 52 or 90 <= ISC <= 92 or ISC = 94, 98, 99, 103, 104), then the person attrited for non-pejorative reasons.

ISC codes:

Medical disqualifications:

- 11- disability - severance pay
- 12 - permanent disability - retired
- 13 - temporary disability - retired
- 14 - disability - non EPTS - no severance pay
- 15 - disability - Title 10 retirement

Death:

- 30 - battle casualty
- 31 - non-battle - disease
- 32 - non-battle - other
- 33 - death - cause not specified

Entry into officer programs:

- 40 - officer commissioning program
- 41 - warrant officer program
- 42 - service academy

Retirement (other than medical)

- 50 - 20-30 years of service
- 51 - over 30 years of service
- 52 - other categories

Other separations or discharges

- 90 - Secretarial authority
- 91 - erroneous enlistment or induction
- 92 - sole surviving family member
- 94 - pregnancy
- 98 - breach of contract
- 99 - other

Transactions:

- 103 - record correction
- 104 - missing in action or POW

APPENDIX B

CMF OCCUPATIONAL CLUSTERS

CMF occupational clusters

Cluster Title	CMF
Administration and accounting	
Administration	71
Recruiting and Retention	79
Arts and public affairs	
Public Affairs	46
Bands	97
Aviation	
Aircraft Maintenance	67
Aviation Operations	93
Civil Affairs	
Civil Affairs	38
Electronic maintenance and calibration	
Electronic maintenance and calibration	35
General engineering	
General Engineering	51
General science	
Chemical	54
Topographic engineering	81
Health Science	
Medical	91
Mechanical maintenance	
Mechanical maintenance	63
Military intelligence technology	
Electronic warfare/intercept system maintenance	33
Military Intelligence	96
Signal intelligence/electronic warfare operations	98
Military Police	
Military Police	95

Military Science

Infantry	11
Combat engineering	12
Field artillery	13
Air defense artillery	14
Special forces	18
Armor	19

Missile maintenance

Air defense system maintenance	23
--------------------------------	----

Psychological operations

Psychological operations	37
--------------------------	----

Signal Corps

Visual information	25
Signal operations	31
Record information operations	74

Supply and services

Ammunition	55
Petroleum and water	77
Supply and services	92
Food service	94

Transportation

Transportation	88
----------------	----
